RECLAMATION

Managing Water in the West

Assessing Climate Change Risks for Water and Power Operations in Reclamation Regions

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Climate Change and Water Resources, Joint HQ Meeting
31 May 2007, USACE Institute for Water Resources, Washington, D.C.

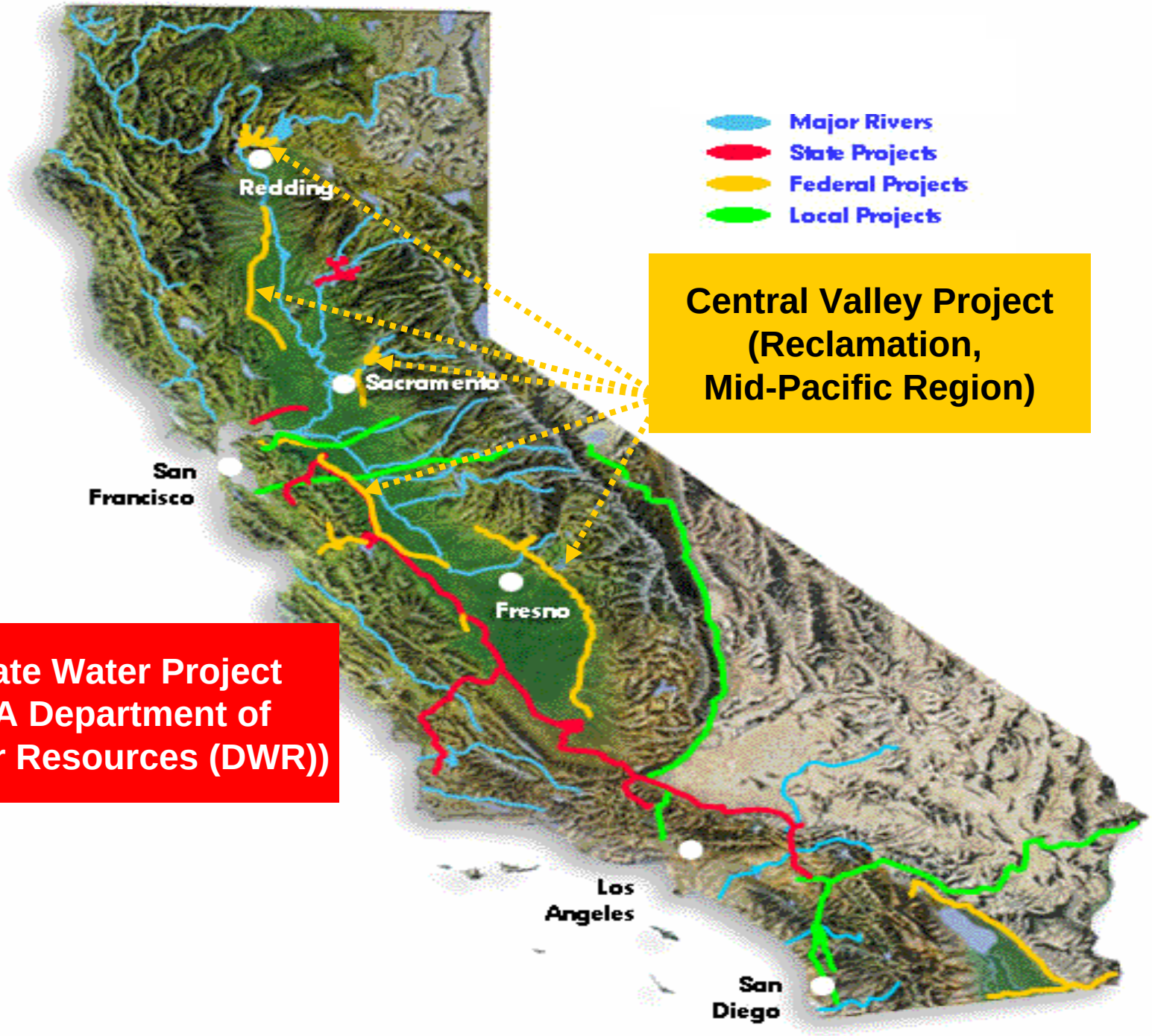
U.S. Department of the Interior
Bureau of Reclamation

Research on Use of Climate Change Information in Long-Term Evaluations

- Several ongoing evaluations
  - LC, MP, PN regions

- Focus here is on:
  - CVP/SWP Climate Change Risk Study (2006-2007)
  - Collaboration: Reclamation, CA DWR, USACE, USGS/Scripps, Santa Clara Univ.

The findings and conclusions of these efforts have not been formally disseminated by Reclamation and should not be construed to represent any agency determination or policy.



Central Valley Project (Reclamation, Mid-Pacific Region)

State Water Project (CA Department of Water Resources (DWR))

CVP/SWP Climate Change Risk Study (FY2006-2007)

- Purpose
  - Support risk-reduction planning
  - Explore use of risk analysis
    - Assessment #1:
      - Projection Uncertainty and Scenario Weights
    - Assessment #2:
      - Scenario-Specific Impacts
    - Merging Results into Risk
      - Scenarios, Impacts & Scenario ~Probabilities (Weights)

ASSESSMENT #1: Projection Uncertainty and Scenario Weights

- Surveyed 75 WCRP CMIP3 climate projections:
  - 17 climate models
  - simulations of SRES A2 or B1

- Considered change in 30-year climate norms (base to future) and fit distributions to "change in norms"
  - Temperature (T), Precipitation (P), and joint {T, P}
  - with and without considering climate model skill
    - *Model skill in simulating past indicates credibility in projecting future*
    - based on 20th Century simulations (59 20C3M runs)

- Used distributions to estimate *relative* probabilities for specific scenarios (i.e. *22 studied for impacts*)

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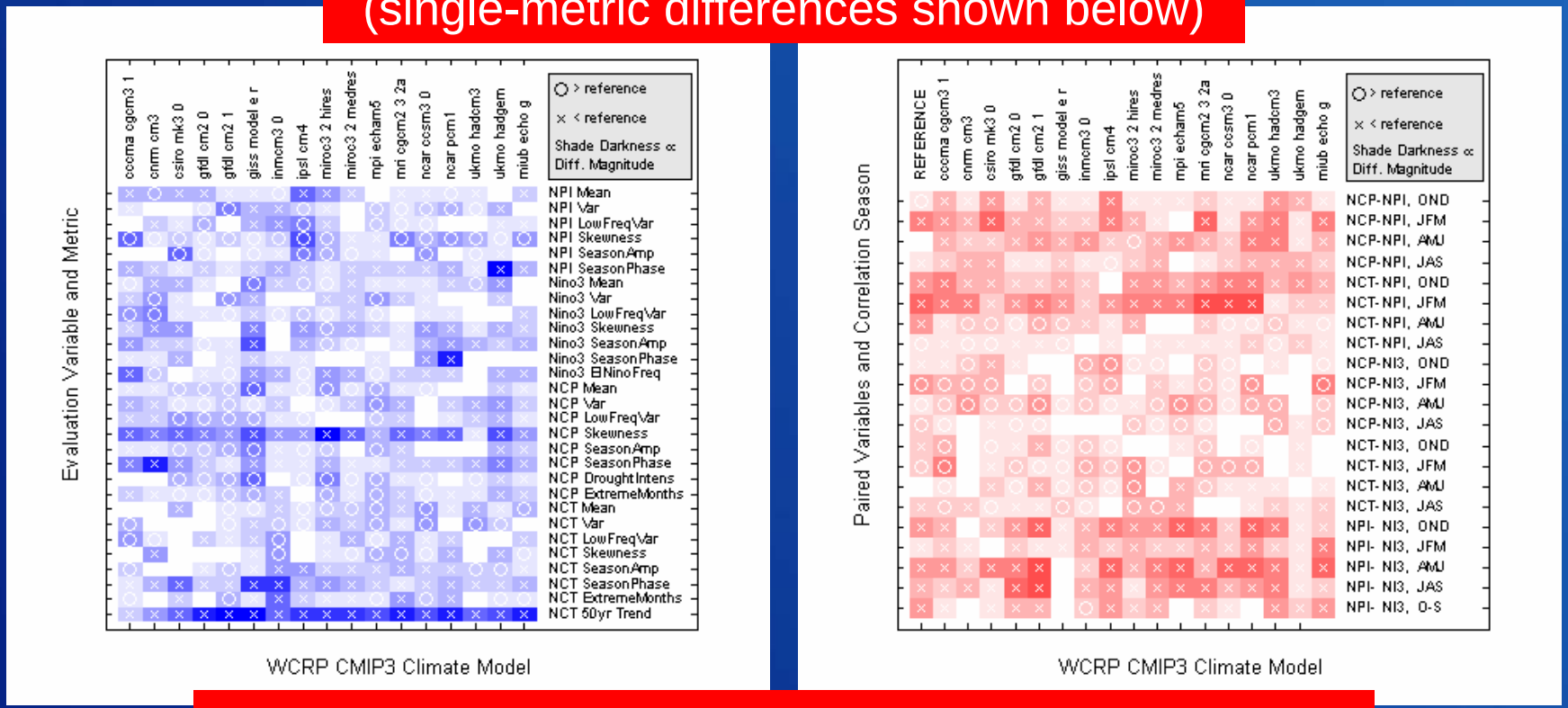
Basis for Assessing Model Skill: Variables & Metrics

Statistic, Metric, or Correlation	Variable, monthly, 1950-1999 Global, Local, or Teleconnections			
	NorCalT	NorCalP	NPI	Nino3
Long-Term Mean				
Long-Term Var.				
Long-Term Var., Interdec.				
Long-Term Skewness				
Mo. Means: Seas. Amp.				
Mo. Means: Seas. Phase				
6yr sum, 90% exc.				
Annual Max Mo. 10% exc.				
El Nino Reoccurrence				
Seasonal Corr with NPI	(4)	(4)		
Seasonal Corr with Nino3	(4)	(4)	(4)	
Annual Corr with Nino3				

Measuring Skill:
Model "Distance" from Reference

Formula: Normalized Euclidean
Dimensions: one or more metrics…
(single-metric differences shown below)

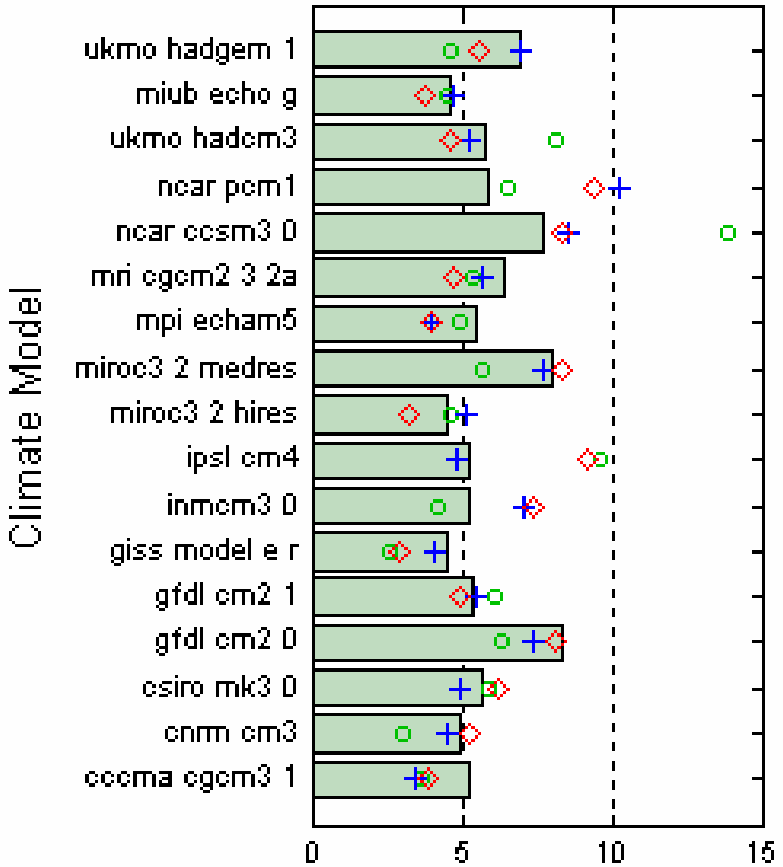


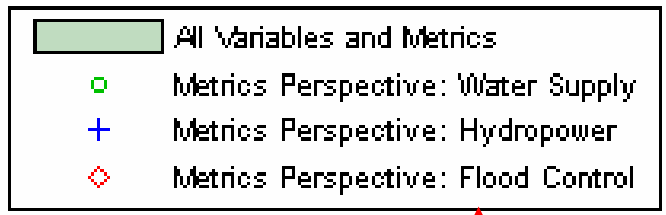
Reference - Atmosphere: NCEP/NCAR Reanalysis
Reference - Sea Surface: Kaplan SST

Culling Models based on Skill:

compute weight as ~ inv. Distance

retain models with weight >= median

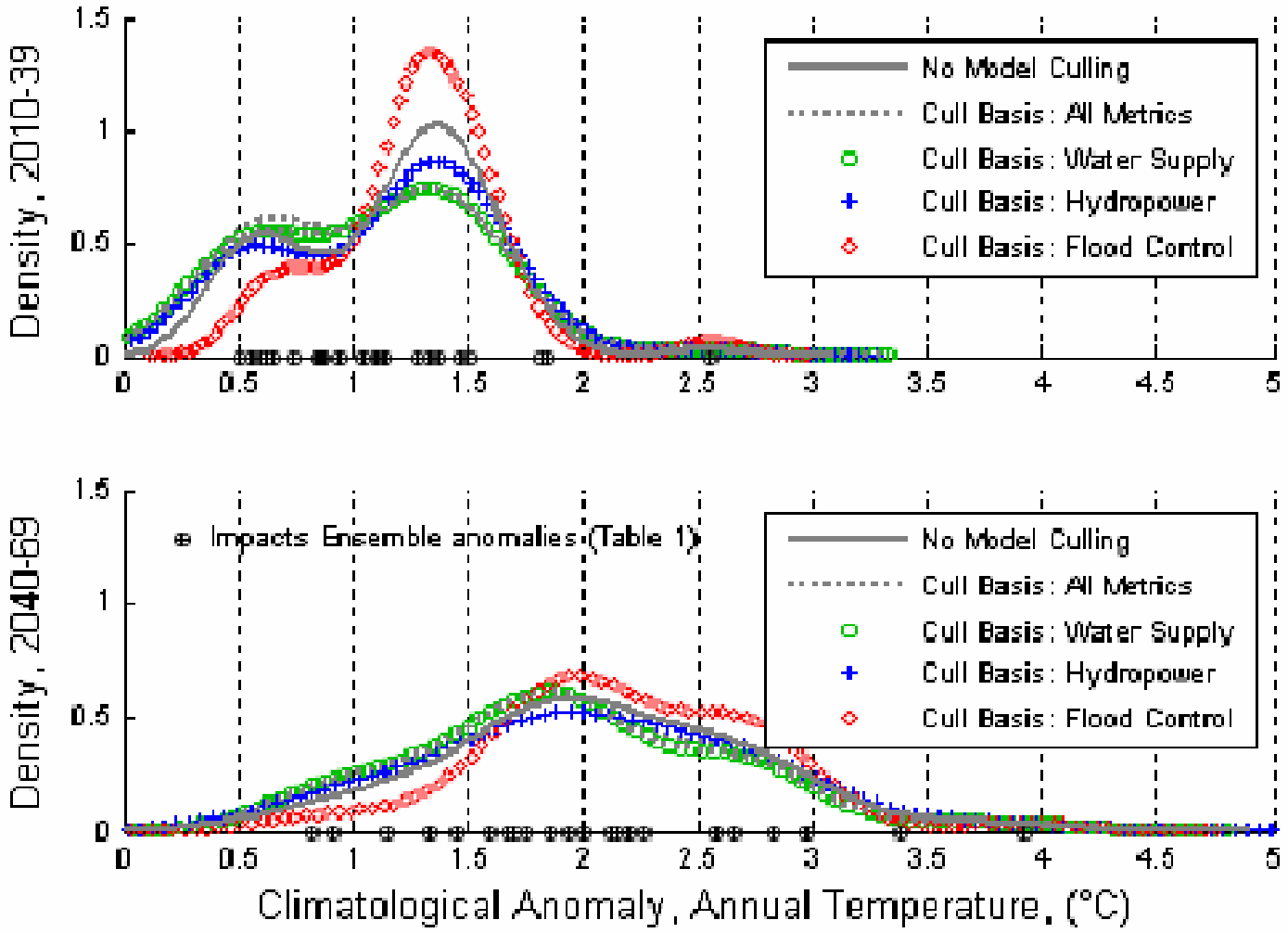




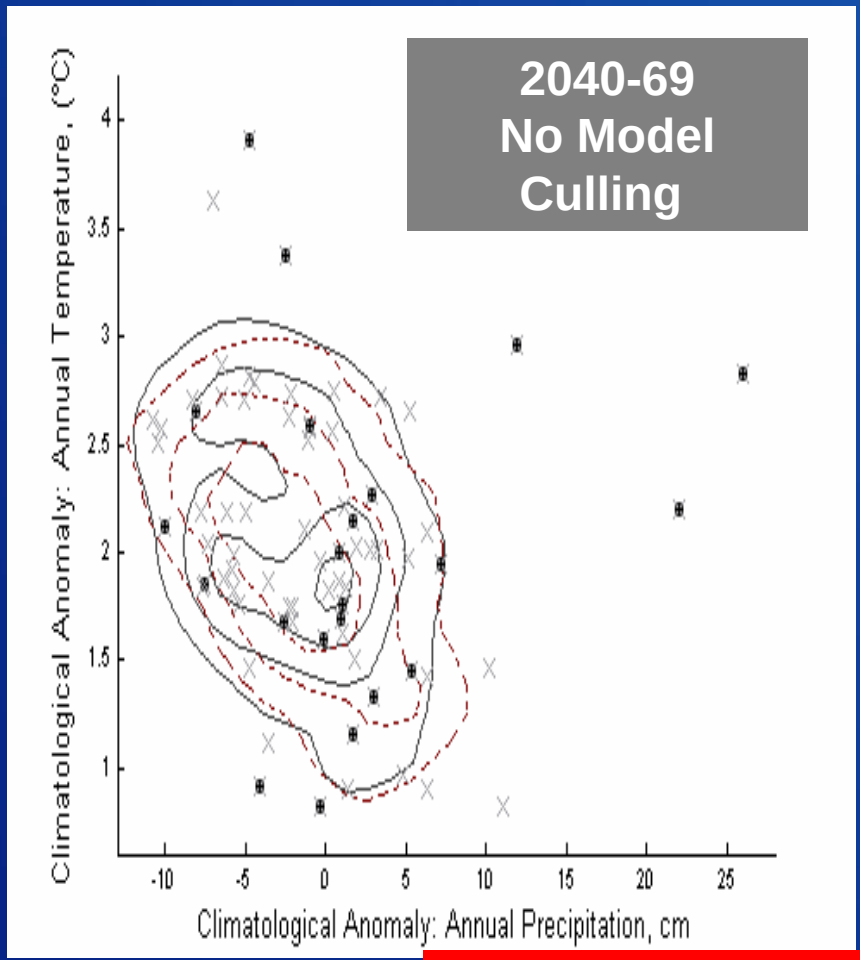
Relative weighting depends on perspective

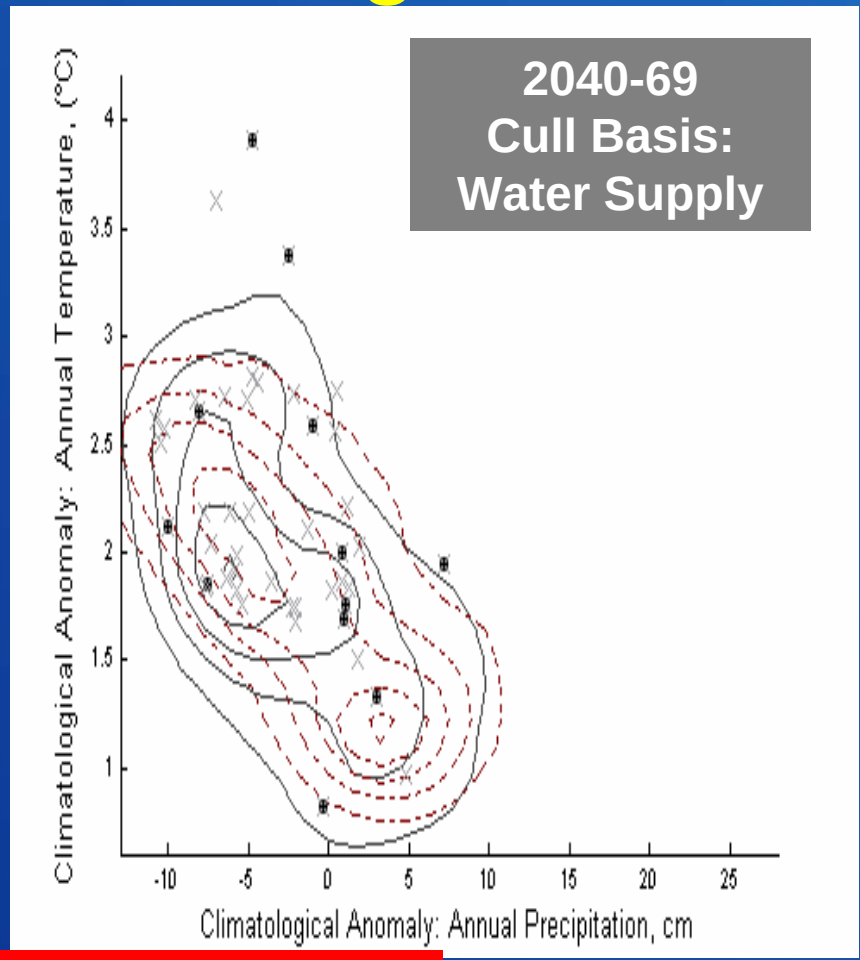
Weights sum to 100, and are based on Euclidean distance between Reference and model, along standardized metrics

Projected T Density Functions: two Futures, multiple Culling bases



Projected {T,P} Density Functions:
one Future, two Culling bases





Gray Contours: No resampling
Red Contours: PCA resampling

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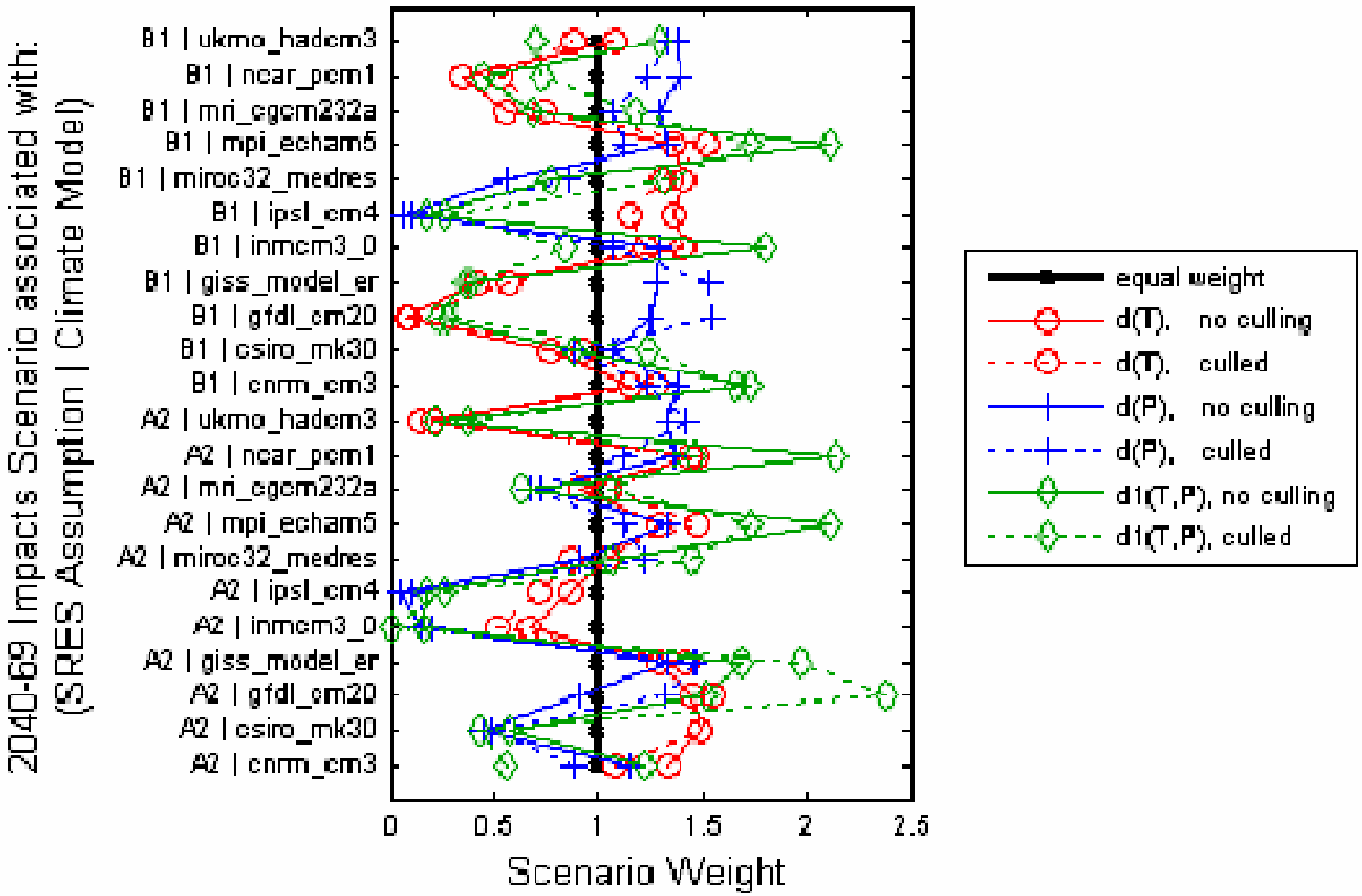
Using Functions to weight Scenarios: different projected variable, cull basis



ASSESSMENT #2: Scenario-Specific Impacts

(Maurer 2007):

22 WCRP CMIP3 projections (11 models each with projections of SRES A2 and B1).

Each projection was:

-- **bias-corrected & spatially downscaled** (Wood et al. 2004)

-- sampled 1963-92, 2011-40, 2041-70 for mean monthly temperature (T) and precipitation (P)

Surface Water Hydrology

Headwater Runoff

Complete

System Operations

Water Deliveries,

Reservoir Storage

Complete

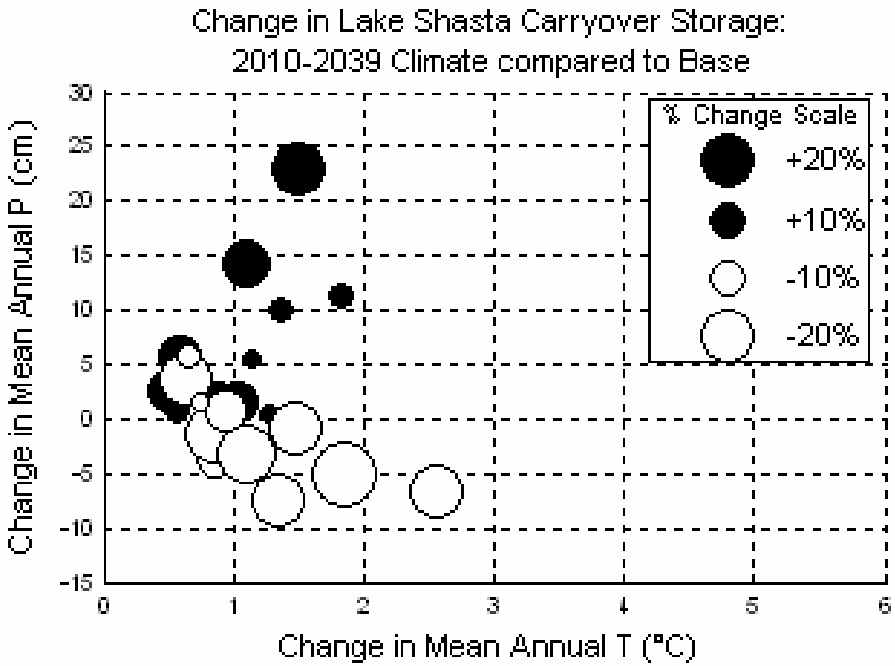
Dependent Effects

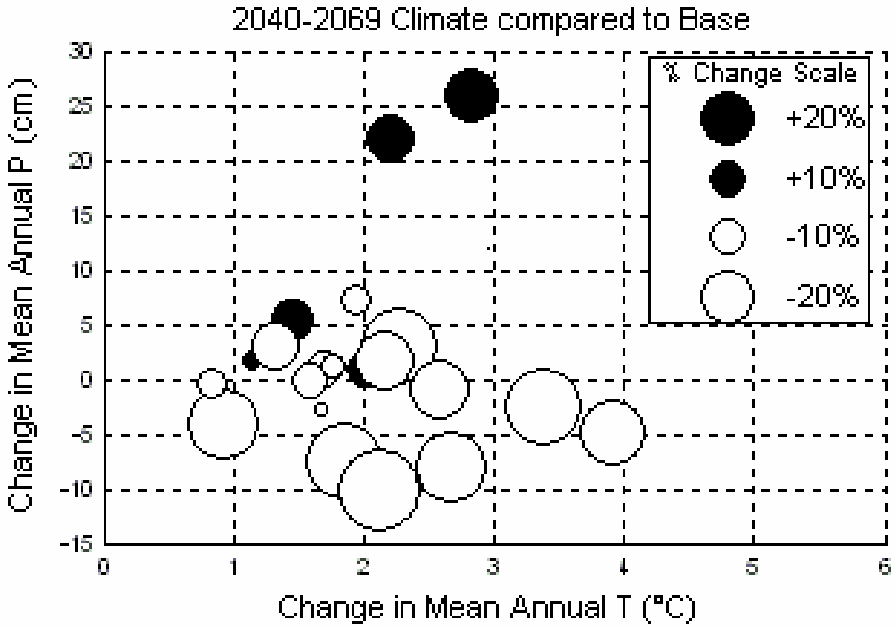
Hydropower;

Stream Temperatures,

Delta Salinity & Water Levels

Current Work





Operations Impact, 22 Scenarios: Carryover at Lake Shasta

- Average end-of-Sept from “Dry” and “Critical” simulation years (Sac40-30-30 Index)
- “Change in Average” plotted versus climate change scenario (T and P change)

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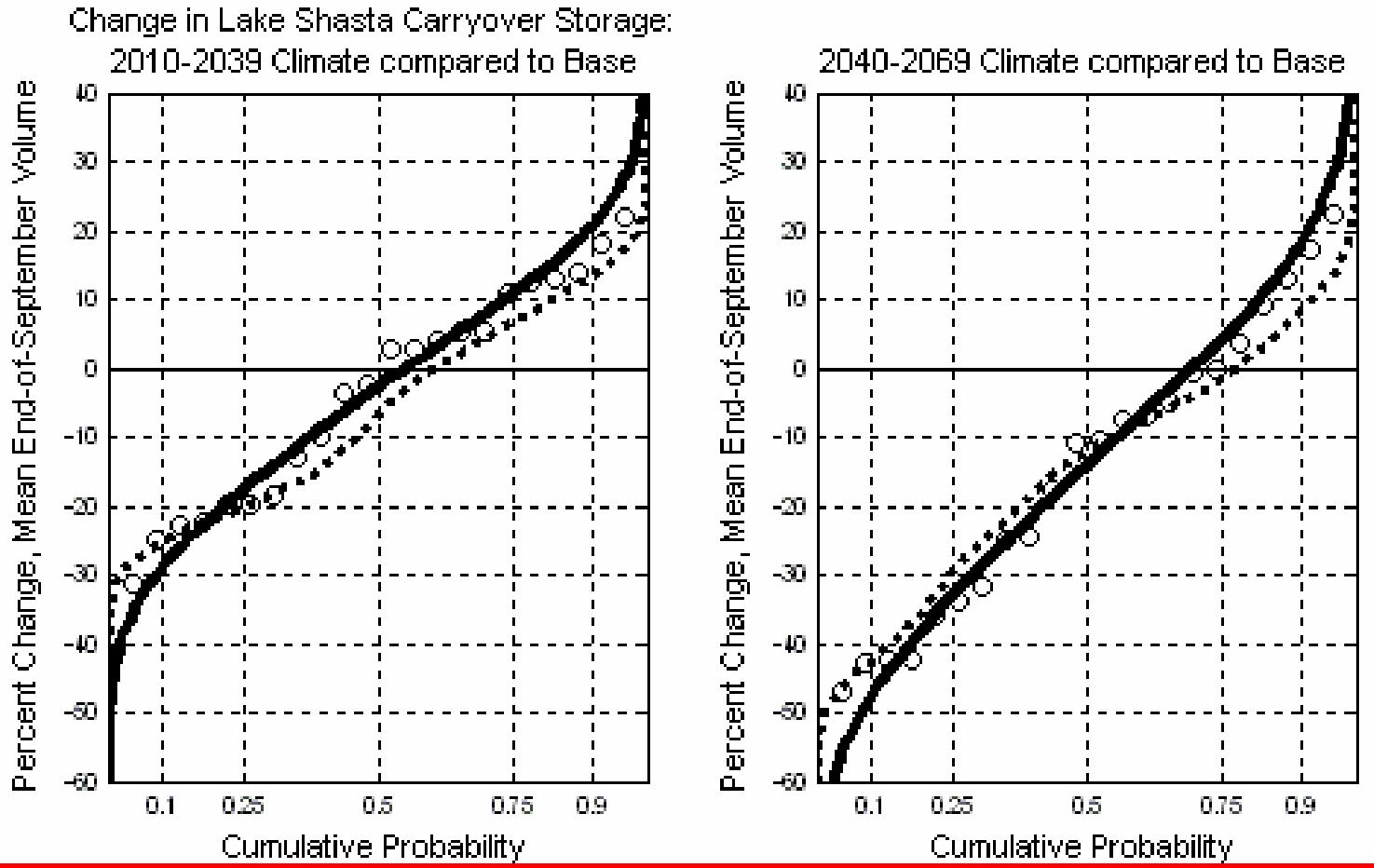
Merging Results into Risk: Carryover at Lake Shasta



Circles: Scenario-specific Impacts
Solid Line: Risk given Equally Weight Scenarios
Dashed Line: Risk given Consensus-based Weighted Scenarios

Perceived Risk depends on Analytical Design…

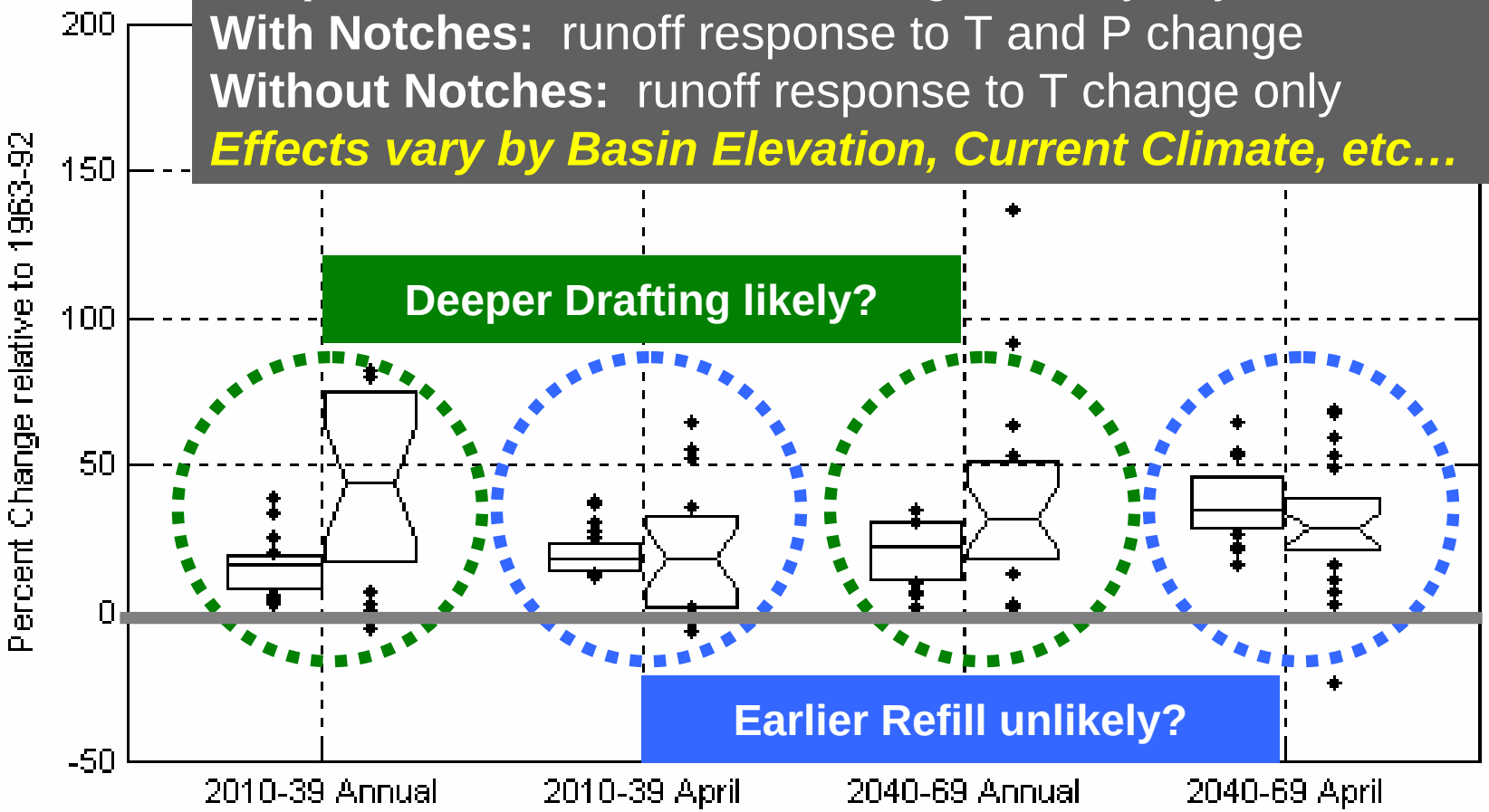
Future Flood Control?

- We analyzed operations risk given contemporary flood control rules.

- Is this a reasonable assumption?
  - Deeper winter drafting?
  - Earlier refill?
  - Basis for Change?
    - Potential Criteria discussed at Spring 2007 workshops with Federal, State, and local flood control operators
    - Decided to focus on change in 3-day peak volume from the 22 scenarios of simulated runoff (30-year simulations)

Effect on Potential 3-Day Runoff: Feather River Middle Fork

Boxplots: 22-scenarios, % change in 3day/30yr max volumes
With Notches: runoff response to T and P change
Without Notches: runoff response to T change only
Effects vary by Basin Elevation, Current Climate, etc…



Projected Precipitation Change?

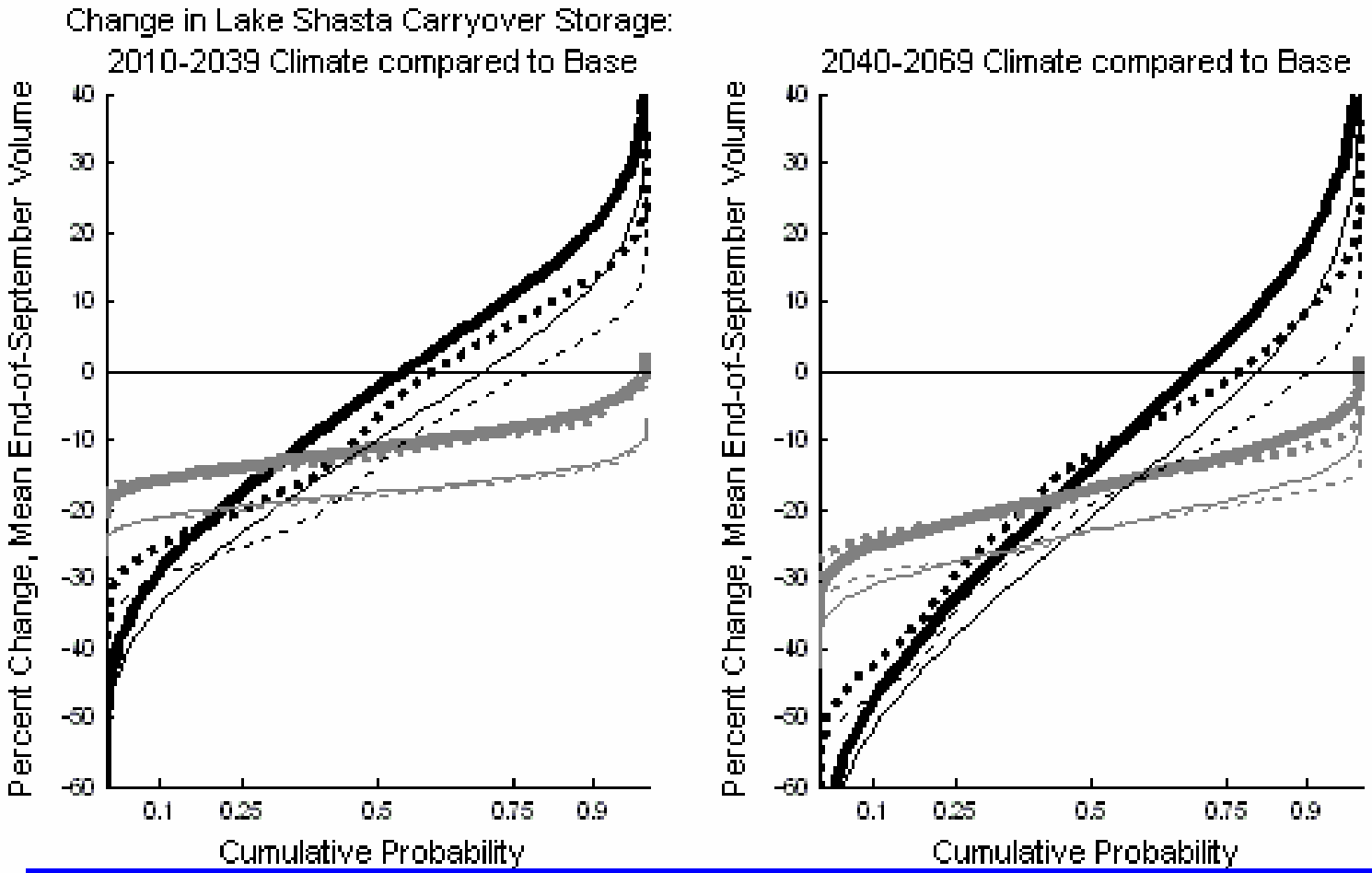
- We analyzed operations risk, accepting P projections over Northern CA as an acceptable portrayal of possibilities.

- Is this a reasonable assumption?
  - What's our paradigm for Northern CA precipitation response to global warming?
  - Is this paradigm derived from model output, or was it hypothesized and then tested by model output?

Assessing Perceived Risk given different Analytical Designs

1. *Scenario Weighting (already discussed)*
   - Equal versus Unequal based on Consensus
2. Assumed Future Flood Control
   - Current versus “Modified”
     - Modifications: (a) no change to Spring Refill rule, (b) increased draft during Nov-Mar (+10%)
3. Assumed Precipitation Change
   - Projected versus Historical

Variations on Perceived Risk:
Carryover at Lake Shasta



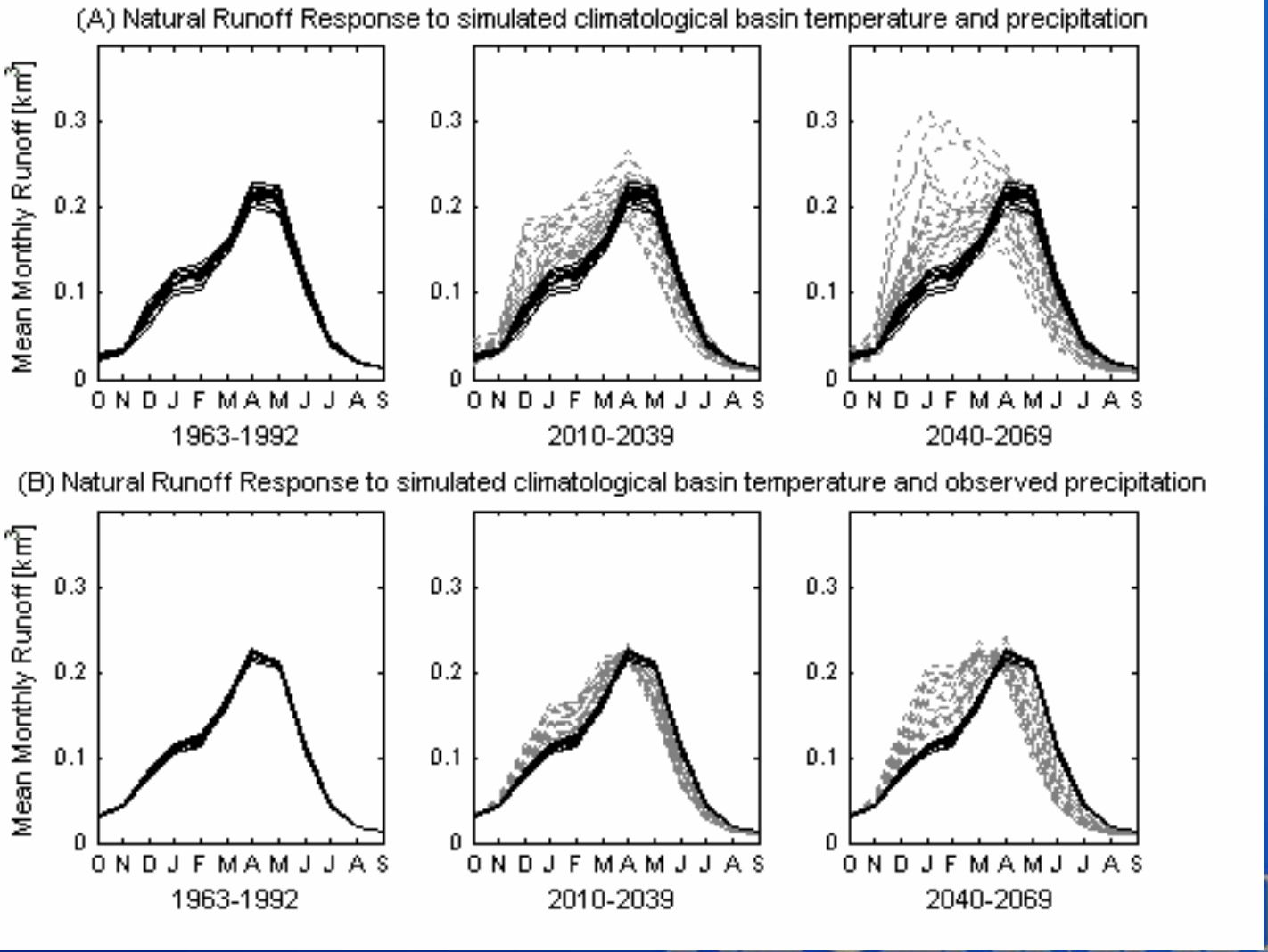
Solid versus Dashed: Equal versus Unequal Scenario Weights
Black versus Gray: {T and P change} versus {T change only}
Thick versus Thin: Current versus Modified Flood Control

Status & Future Work

- Analyses complete
  - Documentation – Projection Uncertainty
    - Brekke, L.D., M.D. Dettinger, E.P. Maurer, and M. Anderson, 2007, "Significance of Model Credibility in estimating Climate Projection Distributions for Regional Hydroclimatological Risk Assessments," *(revised July 2007, submitted to Climatic Change, in review)*
  - Documentation – Risk Analysis
    - "Analytical Design Influences on Climate Change Risk Assessment for Reservoir Operations" *(in preparation, submit to peer-review Oct 2007)*
- Future Work
  - Support efforts to evaluate projected P uncertainty
  - Evaluate natural and social water demand effects
  - Explore risk-reduction strategies

Extras

Runoff Impact, 22 Scenarios: (Feather River, Middle Fork)



Effects on Perceived Risk: Summary

- Unequal Scenario Weighting
  - Minor effect on risk, perceived range of impact
- Modified Future Flood Control
  - Major effect on centrally expected impact
- No Precipitation Change
  - Major effect, reduced range of impacts, shift in centrally expected impact
  - ~2/3 of perceived risk from projected P change